

## Chapter 6

# RIOT-CONTROL AGENTS

### Summary

**NATO Codes:** CS, CN, CR, DM, and OC

**Signs and Symptoms:** Burning and pain on exposed mucous membranes and skin, eye pain and tearing, burning in the nostrils, respiratory discomfort, and tingling of the exposed skin. DM causes prolonged periods of vomiting and a feeling of malaise.

**Field Detection:** No field detector is available for any of the riot-control agents.

**Decontamination:** *Eyes:* Thoroughly flush with water, saline, or similar substance. *Skin (CS, CN, CR, and DM):* Flush with copious amounts of water, soap and water, or a mildly alkaline solution (sodium bicarbonate or sodium carbonate). Generally, decontamination is not needed if the wind is brisk. *Skin (OC):* The pain from OC will increase with water, especially warm water. It is best decontaminated with baby shampoo, milk, alcohol, or vegetable oil. Without decontamination pain will subside over time.

**Management:** Usually none is necessary; effects are self-limiting and diminish or cease within 45 minutes. DM is the exception; its effects may last several hours.

### Overview

Riot-control agents, also called irritants, lacrimators, and tear gas, produce transient discomfort and eye closure, rendering

the recipient temporarily incapable of fighting or resisting. Law enforcement agencies use them for riot control, and military forces use them for training and in combat. They have a high median lethal concentration ( $LCt_{50}$ ) and a low median effective concentration ( $ECt_{50}$ ), and therefore a high safety ratio. Their major effect is to cause pain, burning, or discomfort on exposed mucous membranes and skin; these effects occur within seconds of exposure but seldom persist more than a few minutes after exposure has ended.

## **History and Military Relevance**

Paris police used riot-control agents to dispel rioters before World War I, and these compounds were the first chemical agents deployed during that war. French soldiers used them with limited success in small skirmishes. About 30 riot-control agents have been developed and used, but their use decreased following the advent of more potent compounds.

After World War I, military and law enforcement agencies used CN (chloroacetophenone) for various purposes until CS (tear gas), a more potent and less toxic compound, synthesized by Corson and Stoughton (hence the nomenclature) in 1928, replaced it in about 1959. The United States used CS extensively in Vietnam primarily for tunnel clearance. The military forces of most countries use CS in training as a confidence builder for the protective mask (the gas chamber exercise), and police forces of many countries (eg., Ireland, France, Russia, and the US) use it for crowd control or during riots.

Today CN is in commercially available devices for self-protection (Mace, Mace Security International, Inc, Cleveland, OH), but CS and oleoresin capsicum (OC) are fast becoming the favorites among law enforcement agencies. Capsaicin is the active ingredient in OC, commercially called pepper spray. Derived from the resin of cayenne peppers, capsaicin has been used in various ways. In small amounts it is used for pain relief; in larger amounts it is used as an irritant and as a tool of torture. Introduced in 1974 in the United States, it is quickly replacing other riot-control agents used in law enforcement across the country because of its safety and the fact that it can be dispensed as a liquid, foam, or

aerosol, or as a powder in paint ball delivery systems. It is best used for individual protection. The United States excludes riot-control agents from international treaty provisions; they may be used in military situations by presidential order, and OC can be used by military law enforcement.

Other riot-control agents include CA (bromobenzyl cyanide), no longer used in the United States because of its low safety margin and caustic nature (it will not be discussed here); CR (dibenz(*b,f*)(1,4)oxazepine), a British agent similar to CS; and DM (also called adamsite), an irritant and vomiting agent. While OC, CS, and CN continue to be used in the United States, CA, CR, and DM are not, but may be used by other nations for riot control.

## **Physiochemical Characteristics**

Unlike most chemical agents, which are liquids under temperate conditions, the riot-control agents CS, CN, CR, and DM are crystallized solids with low vapor pressures and are dispersed as fine particles or in solution. Dispersion devices include small, handheld spray cans; large spray tanks; grenades; and larger weapons. OC is an oily resin, which can be dried to form an off-white powder and aerosolized or combined with a medium such as alcohol or oil to make a liquid or foam spray.

## **Mechanism of Toxicity**

The mechanism of biological activity is less well characterized for riot-control agents than for most other agents. Fortunately, a detailed knowledge of the mechanism of action is not necessary for appropriate medical management. CS and CN are  $SN_2$  alkylating agents (mustard, in contrast, is an  $SN_1$  alkylator) and react readily at nucleophilic sites. Prime targets include sulfhydryl-containing enzymes such as lactic dehydrogenase. In particular, CS reacts rapidly with the disulfhydryl form of lipoic acid, a coenzyme in the pyruvate decarboxylase system. It has been suggested that tissue injury may be related to inactivation of certain of these enzyme systems. Pain can occur without tissue injury and may be bradykinin mediated. CS causes bradykinin release *in vivo* and *in vitro*, and elimination of bradykininogen

in vivo abolishes the systemic response to CS.

The initial response to aerosolized CS is an increase in blood pressure and irregular respiration, suggestive of the Sherrington pseudoaffective response. Bypassing the pain receptors of the nose and upper airway by endotracheal administration of CS leads to the same decrease in blood pressure; intravenous (IV) injection also causes decreased respiration. These effects suggest that the initial pressor effect and irregular respiration are responses to a noxious stimulus rather than pharmacological effects of CS.

OC produces a burning and painful sensation as it binds to ion-channel receptors in the nervous system, resulting in rapid cell depolarization and a massive release of substance P, a neuropeptide that is a neurotransmitter of pain. This release of high levels of substance P signals the brain that the body is experiencing extreme pain and burning, which continues until the substance P is used up. The body then releases endorphins to inhibit the pain sensation, which can create a period of euphoria (similar to a “runners high”) as an after-effect. Those who regularly eat hot peppers are less susceptible to the painful effects of pepper spray. The use of capsaicin in pain-relieving ointments causes a slower release and depletion of substance P, creating an analgesic effect without causing the extreme pain sensation experienced with OC exposure.

## **Clinical Effects**

The main effects of riot-control agents are pain, burning, and irritation of exposed mucous membranes and skin. These effects do not differ appreciably from one agent to another, except in the case of DM, which will be discussed in a separate section.

### ***Eyes***

The eye is the organ most sensitive to riot-control agents. Contact with any of the riot-control agents produces a sensation of conjunctival and corneal burning and leads to tearing, blepharospasm, and conjunctival injection. The severe blepharospasm causes the lids to close tightly and produces

transient “blindness,” an effect that can inhibit the recipient’s ability to fight or resist. However, if recipients are able to open their eyes, the vision is near normal even if a significant concentration of the agent persists.

Because these compounds are solids, with the exception of OC, it is possible for a particle or clump to become embedded in the cornea or conjunctiva and cause tissue damage. With the caveat noted below, there is no evidence that this complication has ever occurred; however, those seeking medical care for eye pain after exposure should have their eyes thoroughly decontaminated and undergo thorough ophthalmic examination. It may be necessary to pick out the particles of agent from tissue. The carriers’ solvents in some OC sprays can cause corneal erosion, so eyes should be decontaminated with copious amounts of water or baby shampoo and water. Follow-up with an ophthalmologist is indicated if complications appear.

### *Nose and Mouth*

Contact with the delicate mucous membranes of the nose produces a burning sensation, rhinorrhea, and sneezing; a similar burning sensation accompanied by increased salivation occurs after contact with the mouth.

### *Airways*

Inhalation causes burning and irritation of the airways, with bronchorrhea, coughing, and a perception of a “tight” chest or an inability to breathe. In research studies, pulmonary function exams done immediately after exposure have shown minimal alterations. In one reported instance, nine Marines without respiratory protection were exposed to high CS concentrations during training and developed transient pulmonary syndrome. All had coughs and shortness of breath, five had hemoptysis, and four, who needed to be hospitalized, had hypoxia. It was discovered that those hospitalized underwent strenuous physical exercise within 36 to 84 hours after exposure. One week after exposure all nine had normal lung function measured by spirometry before and after exercise.

An inhaled irritating compound might be expected to exacerbate a chronic pulmonary disease such as asthma, emphysema, or bronchitis, but this appears not to happen with CS or CN. The medical care provider should nevertheless anticipate airway problems in individuals with lung disease, particularly if they are exposed to higher than the average field use concentrations. The onset of extreme pain for those exposed to OC has resulted in a few cases of laryngospasm as a reaction to pain. These cases have responded well with standard airway management.

There is no evidence that CS causes permanent lung damage after one or several exposures to field concentrations. Following inhalation of lethal amounts, animals died from severe airway damage 12 to 24 hours postexposure, but survivors from large exposures had minimal or no pulmonary abnormalities. After multiple (50 or more) daily exposures to smaller amounts, animals developed laryngitis and tracheitis.

### ***Skin***

Riot-control agents in contact with the skin cause a tingling or burning sensation and may cause erythema, particularly if the skin is raw or freshly abraded (eg, shortly after shaving). The erythema begins several minutes after exposure and generally subsides 45 to 60 minutes after termination of exposure.

Under conditions of high temperature, high humidity, and high concentration of agents such as CS, there may be more severe dermatitis, starting with erythema hours after exposure and followed by vesication. Generally these are second-degree burns similar to sunburn but more severe. Firefighters who entered buildings contaminated with CS after summer riots several decades ago developed these lesions. After stirring up the contaminating particles, they later developed erythema and blisters on their exposed skin. Hypersensitivity may develop for those who have reacted to CS in the past. In one instance, an individual developed generalized vesication and high fever after an uneventful exposure to CS more than 20 years after his only and equally uneventful previous exposure. OC causes skin redness and irritation and possibly, with prolonged exposure to high concentrations, a rash, but not the blistering seen with CS or CN.

### ***Gastrointestinal Tract***

Gastrointestinal effects usually do not occur with most riot-control agents (DM is an exception), although there may be retching or vomiting if the agent concentration is high, exposure is prolonged, or the individual is sensitive.

### ***Cardiovascular***

A transient increase in heart rate and blood pressure has occurred in people when exposure to riot-control agents was imminent or immediately after exposure. The heart rate and blood pressure returned essentially to pre-test ranges while exposure continued, and may have been caused by the anxiety or the initial pain rather than a pharmacological effect of these agents. This “alarm reaction” may cause adverse effects in those with preexisting cardiovascular disease.

### ***Oral Ingestion***

Taking large amounts of capsicum orally can increase the production of stomach acid, but this effect would not be caused by ingestion of minute amounts of OC from a spray or foam. Children occasionally eat CS, and several adults have swallowed CS pellets. Aside from bouts of diarrhea and abdominal cramps (which might have been from the cathartics and antacids used as therapy), their courses have been uneventful. In humans, the median lethal dose ( $LD_{50}$ ) for CS is an amount unlikely to be ingested, even deliberately. A few animals fed lethal amounts (or greater) of CS had gastric irritation or erosions, and several had signs of intestinal perforation. Recommended therapy after ingestion consists of cathartics, antacids, and surgical observation.

### ***Lethality***

Riot-control agents should not be considered nonlethal. They can be lethal when the exposure involves a high concentration or longer period of time. CN, occasionally in combination with DM, has caused deaths in people in a confined space. The confined space contributed to a higher concentration and a

longer exposure to the agent. Death generally occurred hours after initial exposure, and postmortem findings were those of severe airway damage. Deaths directly attributed to OC exposure are not easily found in the literature, though theoretically severe laryngospasm could cause respiratory restriction and possible obstruction, hypoxia, and unconsciousness. Those in police custody who died after exposure to OC died from preexisting cardiopulmonary conditions, drug intoxication, or positioning while restrained that restricted breathing, but no deaths have been directly attributed to the actions of OC.

### ***Metabolism***

Subjects given lethal amounts of CS by IV or intraperitoneal (IP) administration developed increased blood thiocyanate concentrations hours later, indicating that the malononitrile portion of CS had been metabolized to cyanide. Cyanide was not a factor in causing death (lung damage was). A significant increase in blood concentration of thiocyanate has not been noted after aerosol administration of CS. Several popular databases mention this cyanogenic potential of CS and suggest that treatment of a CS casualty might require therapy for cyanide poisoning (this recommendation is apparently based on the IV or IP administration data). After receiving lethal amounts of CS by inhalation, animals died 12 to 24 hours later from severe airway damage; cyanide was not implicated in their deaths.

OC will cause depletion of substance P over time; once substance P is depleted, pain stops. The body rebuilds substance P stores over several hours to days. OC is absorbed in the body. Those who are exposed to capsaicin for long periods of time, such as in food or topical salves for pain management, have depleted stores of substance P and may not demonstrate as extreme a pain reaction to the administration of OC as others.

### ***DM***

DM typically appears as a canary yellow, crystalline solid and has the same unique color when dispensed as a cloud. The effects of usual field concentrations of DM are similar to those of the other riot-control agents, except that DM has little irritancy to



the skin. However, at higher concentrations, DM causes nausea, vomiting, and a feeling of generalized malaise. For this reason, it is called a vomiting agent.

## **Time Course of Effects**

Except for those produced by DM, the biological effects from these agents begin seconds after exposure and continue for 15 minutes or so after those exposed exit the contamination to fresh, clean air. The effects from DM begin 2 to 4 minutes after the onset of exposure and may last an hour or two. (This is advantageous militarily, because an individual unaware of the agent will continue to inhale it for several minutes and absorb a larger dose. He or she may then vomit, requiring mask removal, which leads to continued inhalation of agent.)

## **Differential Diagnosis**

Usually the circumstances of exposure help make the diagnosis. The patient history and the physical signs clarify the diagnosis. A patient with conjunctival injection (red eye) and tearing may have a wide differential. Closer examination may reveal normal pupils, whereas a nerve agent exposure would present with constricted pupils. On a battlefield, the sudden onset of burning pain and irritation might lead one to consider lewisite or phosgene oxime exposure, but the signs and symptoms of riot-control agents gradually recede, whereas those from the vesicants worsen.

## **Laboratory Findings**

There are no specific laboratory tests that will confirm the diagnosis. Complications such as infection of a skin lesion will produce the laboratory findings characteristic of the complication.

## **Medical Management**

The effects of exposure to these agents under the usual field conditions generally are self-limiting and require no specific

therapy. Most will disappear in 15 to 30 minutes, although erythema may persist for an hour or longer. The following section discusses potential complications occurring only under exceptional circumstances, such as exposure to a very large amount of agent (as in an enclosed space), exposure in adverse weather, or experimental studies in humans or animals. These conditions are not to be expected with normal use of these agents. Less than 1% of exposed people will have effects severe or prolonged enough to cause them to seek medical care. Those who do probably will have eye, airway, or skin complaints. Because there is no antidote for these agents, treatment consists of symptomatic management.

### ***Eyes***

The eye should be carefully flushed with water or saline, and impacted particles should be sought. General care consists of a topical solution (many are available) to relieve the irritation and topical antibiotics. An ophthalmologist should be consulted for further evaluation and care. With exposure to OC, milk, vegetable oil, or baby shampoo and copious amounts of water can be effective for eye washing.

### ***Pulmonary***

These agents may exacerbate chronic disease or unmask latent disease, although there is little evidence of this. Bronchospasm with wheezing and mild distress continuing hours after exposure may occur in a latent asthmatic. More severe effects and respiratory distress may occur in those with chronic bronchitis or emphysema. Management includes oxygen administration (with assisted ventilation, if necessary), bronchodilators if bronchospasm is present, and specific antibiotics dictated by the results of sputum studies (Gram stains of smears followed by culture). A specialist skilled in the treatment of inhalation injury should be consulted early. Animal studies and very limited human data indicate that maximal effects occur 12 hours after exposure.

## ***Skin***

Those with early erythema require reassurance, but no specific therapy unless the condition is severe and prolonged more than an hour or two. Later onset erythema precipitated by a larger exposure in a hot and humid atmosphere is usually more severe and less likely to resolve quickly. It may require the use of soothing compounds such as calamine, camphor, and mentholated creams. Small vesicles should be left intact, but larger ones will ultimately break and should be drained. Irrigation of denuded areas several times a day should be followed by the application of a topical antibiotic. Large, oozing areas have responded to compresses containing substances such as colloidal oatmeal, Burow solution, and other dermatologic preparations.

## **Decontamination**

The crystallized solids CS, CN, CR, and DM can be released from hair, skin, and clothing by flapping the arms or using fans. Although many of these agents are not directly soluble in water, washing with soap and water will effectively remove them from the skin. Washing with soap and water is particularly important for those exposed to the agents for long periods of time, such as an individual operating in a mask confidence chamber. Water increases the pain of OC, so if it is used it should be with copious volumes to help remove the OC from the skin surface. A mild soap, such as baby shampoo, will help loosen resin, as will vegetable oil or alcohol. Casein in milk helps reduce the further release of substance P. Milk, with its lipophilic casein, will also effectively combine with the capsaicin resin to help wash it away.

## **Triage**

A person exposed to the usual field concentrations of riot-control agents will probably not be seen at a triage area. Those presenting with complications should be triaged according to the nature of their injuries.

## **Return to Duty**

Because the effects of field concentrations clear within minutes, the casualty can be returned to duty as soon as possible. Casualties with complications may require evacuation and further medical treatment.